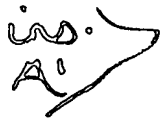## INHALATION OF AEROSOL ACTIVES

The present invention relates to a method of
reducing the inhalation of compositions which are
5   sprayed into the atmosphere, in particular those which
are sprayed from an aerosol spray device.

Aerosols spray compositions produce potential
health/breathing hazards through the inhalation of the
spray particles or droplets. It is known that, for
10 example, so-called PM10 particles (herein defined as
those particles with a particle size of less than 10
micrometres) are capable of travelling deep into the
respiratory tract. A typical aerosol spray device
will produce liquid droplets with a range of droplet
15 diameters, but usually a proportion of the droplets
have a droplet diameter of less than 10 micrometres.

We have now developed a method whereby the
inhalation of aerosol compositions can be reduced.

According to the present invention there is
20 provided a method of reducing the inhalation of
airborne/respirable particles or droplets having a
diameter of less than 10 micrometres, produced by
spraying liquid droplets from a spray device, which
method comprises imparting a unipolar charge to the
25 liquid droplets by double layer charging during the
spraying of the droplets from a spray device, the
unipolar charge being at a level such that the
droplets have a charge to mass ratio of at least +/- 1
x 10^{-4} C/kg, whereby at least 10% by volume of the
30 airborne respirable particles or droplets having a
diameter of less than 10 micrometres in the vicinity

of the mouth, nose or upper respiratory tract do not enter the lungs.

It is preferred that the unipolar charge which is imparted to the liquid droplets is generated solely by the interaction between the liquid within the spray device and the spray device itself as the liquid is sprayed therefrom. In particular, it is preferred that the manner in which a unipolar charge is imparted to the liquid droplets does not rely even partly upon the connection of the spray device to any external charge inducing device, such as an external source of relatively high voltage, or any internal charge inducing device such as a battery. With such an arrangement, the spray device is entirely self-contained making it suitable for use both in industrial, institutional and domestic situations.

Preferably, the spray device is a domestic pressure-spraying device devoid of any electrical circuitry but which is capable of being hand held. Typically such a device has a capacity in the range of from 10ml to 2000ml and can be actuated by hand, or by an automatic actuating mechanism. A particularly preferred domestic device is a hand-held aerosol can.

Preferably, therefore the charge to mass ratio of at least +/- 1 x 10^{-4} C/kg is imparted to the liquid droplets as a result of the use of an aerosol spray device with at least one of the features of the material of the actuator, the size and shape of the orifice of the actuator, the diameter of the dip tube, the characteristics of the valve and the formulation of the composition contained within the aerosol spray

device being chosen in order to achieve the said droplet charge to mass ratio by double layer charging imparting the unipolar charge to the droplets during the actual spraying of the liquid droplets from the orifice of the aerosol spray device.

As a result of the method of the present invention, the liquid droplets which form the aerosol spray produced by the spray device carry an electrostatic charge. The charged droplets will seek to disperse as a result of mutual repulsion and will preferentially move towards surfaces having an opposite or a neutral charge, such as the face, nose or in the upper respiratory tract, rather than penetrating into the lungs of humans or animals in the vicinity of the aerosol spray. The higher the charge on the liquid droplets which form the aerosol spray, the more readily they will seek to deposit on the mouth, nose or upper respiratory tract. The rate of flow of the liquid product as it is dispensed from the spray device will also have an effect on the amount deposited with lower flow rates encouraging more deposition than higher flow rates.

The method of the present invention has application in connection with all or most aerosol spray devices in current use, examples being paint aerosols, antiperspirants, hair sprays, insecticides, horticultural products, air fresheners, waxes and polishes, oven cleaners, starches and fabric finishes, shoe and leather care products, glass cleaners and various other household, institutional, professional or industrial products.

The method of the present invention prevents at least 10%, preferably at least 25%, and more preferably at least 40%, yet more preferably at least 75% by volume and even more preferably at least 85% by volume of the airborne particles having a size of less than 10 micrometres from entering the lungs.

The airborne particles may either comprise the liquid droplets per se, or may comprise particles which are produced as the droplets break up or evaporate after spraying.

In general, the liquid composition which is sprayed into the air using the spray device is a water and hydrocarbon mixture, or emulsion, or a liquid which is converted into an emulsion by shaking the spraying device before use, or during the spraying process.

While all liquid aerosols are known to carry a net negative or positive charge as a result of double layer charging, or the fragmentation of liquid droplets, the charge imparted to droplets of liquid sprayed from standard devices is only of the order of +/- 1×10^{-8} to 1×10^{-5} C/kg.

The invention relies on combining various characteristics of an aerosol spray device so as to increase the charging of the liquid as it is sprayed from the aerosol spray device.

A typical aerosol spray device comprises:

1. An aerosol can containing the composition to be sprayed from the device and a liquid or gaseous propellant;

2. A dip tube extending into the can, the upper

end of the dip tube being connected to a
valve;

　　　3.　　An actuator situated above the valve which
is capable of being depressed in order to operate the
5　　valve; and

　　　4.　　An insert provided in the actuator
　　　　　comprising an orifice from which the
　　　　　composition is sprayed.

　　　A preferred aerosol device for use in the
10　　present invention is that described in WO 97/12227.

　　　It is possible to impart higher charges to the
liquid droplets by choosing aspects of the aerosol
device including the material, shape and dimensions of
the actuator, the actuator insert, the valve and the
15　　dip tube and the characteristics of the liquid which
is to be sprayed, so that the required level of charge
is generated as the liquid is dispersed as droplets.
A number of characteristics of the aerosol system
increase double layer charging and charge exchange
20　　between the liquid formulation and the surface of the
aerosol system.　Such increases are brought about by
factors which may increase the turbulence of the flow
through the system, and increase the frequency and
velocity of contact between the liquid and the
25　　internal surface of the container and valve and
actuator system.

　　　By way of example, characteristics of the
actuator can be optimised to increase the charge
levels on the liquid sprayed from the container. A
30　　smaller orifice in the actuator insert, of a size of
0.45mm or less, increases the charge levels of the

liquid sprayed through the actuator.   The choice of
material for the actuator can also increase the charge
levels on the liquid sprayed from the device with
material such as nylon, polyester, acetal, PVC and
5   polypropylene tending to increase the charge levels.
The geometry of the orifice in the insert can be
optimised to increase the charge levels on the liquid
as it is sprayed through the actuator. Inserts which
promote the mechanical break-up of the liquid give
10   better charging.

The actuator insert of the spray device may be
formed from a conducting, insulating, semi-conducting
or static-dissipative material.

The characteristics of the dip tube can be
15   optimised to increase charge levels in the liquid
sprayed from the container. A narrow dip tube, of for
example about 1.27mm internal diameter, increases the
charge levels on the liquid, and the dip tube material
can also be changed to increase charge.

20   Valve characteristics can be selected which
increase the charge to mass ratio of the liquid
product as it is sprayed from the container. A small
tailpiece orifice in the housing, of about 0.65mm,
increases the charge to mass ratio during spraying. A
25   reduced number of holes in the stem, for example 2 x
0.50mm, also increases the charge during spray. The
presence of a vapour phase tap helps to maximise the
charge levels, a larger orifice vapour phase tap of,
for example, about 0.50mm to 1.0mm generally giving
30   higher charge levels.

Changes in the product formulation can also

affect charging levels. A formulation containing a
mixture of hydrocarbon and water, or an emulsion of an
immiscible hydrocarbon and water, will carry a higher
charge to mass ratio when sprayed from the aerosol

5   device than either a water alone or hydrocarbon alone
formulation.

It is preferred that a liquid composition of use
in the present invention comprises an oil phase, an
aqueous phase, a surfactant and a propellant.

10   Preferably the oil phase includes C_9 - C_{12} hydrocarbon
which is preferably present in the composition in an
amount of from 2 to 10% w/w.

Preferably the surfactant is glyceryl oleate or
polyglycerol oleate, preferably present in the

15   composition in an amount of from 0.1 to 1.0% w/w.

Preferably the propellant is liquified petroleum
gas (LPG) which is preferably butane, optionally in
admixture with propane. The propellant may be present
in an amount of from 10 to 90% w/w depending upon

20   whether the composition is intended for spraying as a
"wet" or as a "dry" composition. For a "wet"
composition, the propellant is preferably present in
an amount of from 20 to 50% w/w, more preferably in an
amount of from 30 to 40% w/w.

25   The liquid droplets sprayed from the aerosol
spray device will generally have diameters in the
range of from 5 to 100 micrometres, with a peak of
droplets of about 40 micrometres. The liquid which is
sprayed from the aerosol spray device may contain a

30   predetermined amount of a particulate material, for
example, fumed silica, or a predetermined amount of a

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volatile solid material, such as menthol or
naphthalene.

A can for a typical aerosol spray device is
formed of aluminium or lacquered or unlacquered tin
5   plate or the like. The actuator insert may be formed
of, for instance, acetal resin. The valve stem
lateral opening may typically be in the form of two
apertures of diameters 0.51mm.

The present invention will now be described, by
10   way of example only, with reference to the
accompanying drawings, in which:-

Figure 1 is a diagrammatic cross section through
an aerosol spraying apparatus in accordance with the
invention;

15   Figure 2 is a diagrammatic cross section through
the valve assembly of the apparatus of Figure 1;

Figure 3 is a cross section through the actuator
insert of the assembly shown in Figure 2;

Figure 4 shows the configuration of the bore of
20   the spraying head shown in Figure 3 when viewed in the
direction A;

Figure 5 shows the configuration of the swirl
chamber of the spraying head shown in Figure 3 when
viewed in the direction B;

25   Figure 6 illustrates the results obtained in
Example 2; and

Figure 7 illustrates the results obtained in
Example.

Referring to Figures 1 and 2, an aerosol spray
30   device in accordance with the invention is shown. It
comprises a can 1, formed of aluminium or lacquered or

unlacquered tin plate or the like in conventional

manner, defining a reservoir 2 for a liquid 3 having a

conductivity such that droplets of the liquid can

carry an appropriate electrostatic charge. Also

5   located in the can is a gas under pressure which is

capable of forcing the liquid 3 out of the can 1 via a

conduit system comprising a dip tube 4 and a valve and

actuator assembly 5. The dip tube 4 includes one end

6 which terminates at a bottom peripheral part of the

10   can 1 and another end 7 which is connected to a

tailpiece 8 of the valve assembly. The tailpiece 8 is

secured by a mounting assembly 9 fitted in an opening

in the top of the can and includes a lower portion 10

defining a tailpiece orifice 11 to which end 7 of the

15   dip tube 4 is connected. The tailpiece includes a

bore 12 of relatively narrow diameter at lower portion

11 and a relatively wider diameter at its upper

portion 13. The valve assembly also includes a stem

pipe 14 mounted within the bore 12 of the tailpiece

20   and arranged to be axially displaced within the bore

12 against the action of spring 15. The valve stem 14

includes an internal bore 16 having one or more

lateral openings (stem holes) 17 (see Figure 2). The

valve assembly includes an actuator 18 having a

25   central bore 19 which accommodates the valve stem 14

such that the bore 16 of the stem pipe 14 is in

communication with bore 19 of the actuator. A passage

20 in the actuator extending perpendicularly to the

bore 19 links the bore 19 with a recess including a

30   post 21 on which is mounted a spraying head in the

form of an insert 22 including a bore 23 which is in

communication with the passage 20.

A ring 24 of elastomeric material is provided
between the outer surface of the valve stem 14 and,
ordinarily, this sealing ring closes the lateral
5   opening 17 in the valve stem 14. The construction of
the valve assembly is such that when the actuator 18
is manually depressed, it urges the valve stem 14
downwards against the action of the spring 15 as shown
in Figure 2 so that the sealing ring 24 no longer
10   closes the lateral opening 17. In this position, a
path is provided from the reservoir 2 to the bore 23
of the spraying head so that liquid can be forced,
under the pressure of the gas in the can, to the
spraying head via a conduit system comprising the dip
15   tube 4, the tailpiece bore 12, the valve stem bore 16,
the actuator bore 19 and the passage 20.

An orifice 27 (not shown in Figure 1) is
provided in the wall of the tailpiece 8 and
constitutes a vapour phase tap whereby the gas
20   pressure in the reservoir 2 can act directly on the
liquid flowing through the valve assembly. This
increases the turbulence of the liquid. It has been
found that an increased charge is provided if the
diameter of the orifice 27 is at least 0.76mm.

25   Preferably the lateral opening 17 linking the
valve stem bore 16 to the tailpiece bore 12 is in the
form of two orifices each having a diameter of not more
than 0.51mm to enhance electrostatic charge
generation. Further, the diameter of the dip tube 4
30   is preferably as small as possible, for example,
1.2mm, in order to increase the charge imparted to the

liquid. Also, charge generation is enhanced if the
diameter of the tailpiece orifice 11 is as small as
possible eg not more than about 0.64mm.

Referring now to Figure 3, there is shown on an
increased scale, a cross section through the actuator
insert of the apparatus of Figures 1 and 2. For
simplicity, the bore 23 is shown as a single
cylindrical aperture in this Figure. However, the
bore 23 preferably has the configuration, for
instance, shown in Figure 4. The apertures of the
bore 23 are denoted by reference numeral 31 and the
aperture-defining portions of the bore are denoted by
reference numeral 30. The total peripheral length of
the aperture-defining portions at the bore outlet is
denoted by L (in mm) and a is the total area of the
aperture at the bore outlet (in mm^2) and the values
for L and $\underline{a}$ are as indicated in Figure 4. L/$\underline{a}$ exceeds
8 and this condition has been found to be particularly
conductive to charge development because it signifies
an increased contact area between the actuator insert
and the liquid passing there through.

Many different configurations can be adopted in
order to produce a high L/$\underline{a}$ ratio without the cross-
sectional area a being reduced to a value which would
allow only low liquid flow rates. Thus, for example
it is possible to use actuator insert bore configura-
tions (i) wherein the bore outlet comprises a
plurality of segment-like apertures (with or without a
central aperture); (ii) wherein the outlet comprises a
plurality of sector-like apertures; (iii) wherein the
aperture together form an outlet in the form of a

grill or grid; (iv) wherein the outlet is generally
cruciform; (v) wherein the apertures together define
an outlet in the form of concentric rings; and
combinations of these configurations. Particularly

5   preferred are actuator insert bore configurations
wherein a tongue like portion protrudes into the
liquid flow stream and can be vibrated thereby. This
vibrational property may cause turbulent flow and
enhanced electrostatic charge separation of the double

10   layer, allowing more charge to move into the bulk of
the liquid.

          Referring now to Figure 5, there is shown a plan
view of one possible configuration of swirl chamber 35
of the actuator insert 22. The swirl chamber includes

15   four lateral channels 36 equally spaced and tangential to
a central area 37 surrounding the bore 23. In use,
the liquid driven from the reservoir 2 by the gas
under pressure travels along passage 20 and strikes
the channels 36 normal to the longitudinal axis of the

20   channels. The arrangement of the channels is such
that the liquid tends to follow a circular motion
prior to entering the central area 37 and thence the
bore 23. As a consequence, the liquid is subjected to
substantial turbulence which enhances the

25   electrostatic charge in the liquid.

          The following Examples illustrate the
invention:-

EXAMPLE 1

An air freshener formulation was produced as
follows:-

5   83% by weight of an *isoparaffin* ~~iso paraffin~~ solvent was
introduced into a mixing vessel and stirred. 0.2% by
weight of butyl hydroxy toluene was added to the
vessel as a corrosion inhibitor and stirring was
continued until a homogenous mixture was obtained.

10   Thereafter, in turn, 5% by weight of polyglycerol
oleate emulsifier and 11.8% by weight of a fragrance
component were added and stirring was again continued
until a homogeneous mixture had been produced.

The mixture constituted the oil phase of the

15   final product. 6% by weight of this oil phase was
placed in a tin plated aerosol can of the type as
described with reference to Figures 1 and 2, having a
spraying head bore configuration as shown in Figure 4
and a spraying head swirl chamber configuration as

20   shown in Figure 5. The actuator insert was formed of
acetal resin.

The valve stem lateral opening 17 was in the
form of *two* apertures of diameter 0.51mm, the vapour
phase tap orifice 27 had a diameter of 0.76mm, the

25   tail pipe orifice 11 had a diameter of 0.64mm and the
diameter of the dip tube 4 was 3mm. 59% by weight of
soft water was then added to the can and thereafter
the valve assembly was fitted onto the can. 35% by
weight of butane was introduced into the can via the

30   valve assembly to achieve a pressure of 40 psi.
On depression of the actuator 18, a fine spray of

liquid droplets having a charge/mass value of -1×10^{-4} C/kg and a flow rate of approximately 1.5 g/sec was obtained. The droplets became rapidly dispersed in the air.

5   The above-described aerosol spray device was compared with a standard, known aerosol spray device loaded with the same air freshener formulation. It was found that, for the same amount of spraying, the quantity of liquid droplets inhaled was significantly

10   less with the above-described device compared with the standard, known device.

EXAMPLE 2

15   A model head with a conducting surface and oral orifice tube was positioned in a booth ($2m^3$) and earthed. Pieces of filter paper (grade 4) sized $1.5cm^2$ were attached to the face at the left of the nose, the right eye and the right side of the mouth.

20   In each test 7g +/- 0.35g of aerosol product was introduced into the booth by a 3 second spray. Aerosol was introduced into the booth from a position of 1.4m behind and 0.25m above the model head. The product used in these tests had the composition given

25   below:

Ingredient	%w/w
Bioallethrin	0.241
Bioresmethrin	0.046
Butylated hydroxytoluene	0.005
Deionised water	51.15
Fluorescein	0.05
H55 (26% w/w propane/butane blend (Boral)	40.000
Norpar 13 (Exxon)	7.500
Perfume	0.100
Polyglycerol oleate	0.900

After spraying, the booth was left for 10 minutes and the filter paper removed.

Fluorescein is not very water soluble, and so a phosphate buffer (pH 7, 0.1M Na_2HPO + $NaH_2PO_4H_2O$) was used to extract the fluorescein from the filter paper. 5ml of buffer was added to the paper and left for 24 hours. The paper was then removed and the sample tested in a fluorimeter. The fluorimeter was set at zero reading when buffer alone was present in the cuvette. Known concentrations of product were made in phosphate buffer to use as calibration samples. Product was sprayed into a vial and 40mg weighed out. 10ml of buffer was added, and 5ml of this was removed and placed in another vial and 5ml of buffer added to get a second concentration of 20mg/10ml. Further dilutions were made in the same way so that concentrations of 10, 5, 2.5, 1.25 and 0.625gm/10ml were obtained. These known concentrations and their

fluorescence readings were then used to find the
regression line. The equation of the line was then
used to determine how much product was present in the
test samples from their fluorescence reading. This

5   value was then divided by the amount of product
sprayed in the test to get a value of the amount of
product landing on the face per gram of product
sprayed and thus removing any effect of a slightly
variable spray length.

10   Charged aerosol was artificially produced by
applying - 10kV to the can, since the presence of
fluorescein made it difficult to charge the spray
naturally. This produced an aerosol with a charge to
mass ratio of -4 X 10^{-4} C/Kg. This was compared with

15   an uncharged aerosol spray of the same composition.
As shown in Figure 6, uncharged sprays deposited
a mean of 0.115mg of product/g sprayed (n=12, s=0.064)
on the face papers. Charged sprays deposited 63% more
product on the face as compared to uncharged sprays.

20   0.305mg of product/g sprayed was collected (n=12,
s=0.172). The difference is significant at
$P < 0.05$ (t=3.59, 22df).

EXAMPLE 3

25

Following the procedure described in Example 2 a
3 second spray of the following composition was
tested.

30

Ingredient	%w/w
Isopar G	4.996
Butylated hydroxytoluene	0.013
Polyglycerol oleate	0.299
Perfume	0.702
Propane/butane blend	58.94
Fluorescein	0.05

Charged aerosol was artificially produced by applying - 10kV to the can, which produced an aerosol with a charge to mass ratio of -2.4 X 10^{-4} C/kg. This was compared with an uncharged aerosol spray of the same composition.

As shown in Figure 7, uncharged spray deposits a mean of 0.099mg of product/g sprayed (s=0.032) on the face targets. Charged sprays deposited 73.5% more product on the face as compared to uncharged sprays, 0.374 mg of product/g sprayed was collected (s=0.09). The difference is significant P<0.05 (t=9.85, 10df).